

Nanotechnology for Sustainable Agriculture: Innovation, Food Security, and Opportunities for the Next Generation

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Abstract

In the face of climate change, declining soil fertility, and increased threats from plant pathogens, nanotechnology has emerged as a powerful enabler of sustainable agricultural development. Our research activities focus on applying nanotechnology—especially nanopesticides, nanofertilizers, nanosensors, and portable sequencing platforms—to protect crops and enhance productivity in Albania's key farming sectors.

Nanopesticides using silver and zinc oxide nanoparticles have demonstrated strong efficacy against major viruses and fungal pathogens (ToBRFV, *Fusarium* spp.), reducing chemical residues and environmental impact [1].

Nanofertilizers with slow or controlled nutrient release mechanisms have improved nutrient uptake efficiency and reduced leaching losses in field crops such as wheat and maize [2].

Nanobiosensors are being deployed for early detection of viral pathogens in grapevines and citrus crops, enabling rapid and localized responses before outbreaks escalate [3].

Nanopore-based sequencing (MinION) is now being explored as an ultra-portable and cost-effective method for real-time in-field detection and characterization of plant pathogens, including complex viral or bacterial infections. This technology enables rapid, multiplexed diagnosis directly from plant material without laboratory delays [3].

Nanotechnology is more than a technological advancement—it represents a shift in how we protect crops, conserve resources, and secure food systems. In Albania, where agriculture is both a strategic and cultural pillar, such innovations are essential for climate-resilient and high-quality production.

To fully unlock this potential, we must support the next generation of scientists—especially women—to take the lead in nanoscience for agriculture. Through their innovation and inclusion, we can shape a future that is more sustainable, more equitable, and more prepared for tomorrow's challenges.

References

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